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Implicit and Explicit Information Mediation in a Virtual Reality Museum Installation and its Effects on Retention and Learning Outcomes

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Abstract: Much research is currently being done in the area of Virtual Reality. This is due to the imminent release of several new pieces of gaming hardware that promises to bring the Virtual Reality (VR) experience into the homes and public spaces of ordinary people. This study attempts to build on the established literature to create a new form of game-technology based museum learning experience which uses VR to give the user a chance to visit the past. Greve Museum has been looking for a new way to visualize historical places like Mosede Fort, an old World War I battery south of Copenhagen in Denmark and the application developed for this study is a game-based Virtual Reality experience, which places the user at this Fort during World War I using the Oculus Rift Head Mounted Display. The application development was based on theories from other works concerned with education theory in games as well as engagement theory. The experiment explored the amount of knowledge retained, depending on how the information was mediated through the game. One version of the game had all the information given by a narrator and the other worked entirely through dialogue and other diegetic sources. The findings indicate that the implicit procedure only was a tad better suited for information retention overall, but that the explicit procedure gave the user a chance to gain better understanding of the situation. The study furthermore leads to several areas of discussion; partly how the setup affected people positively but also possible future aspects for the implementation.

Keywords: mediation, VR, museum, engagement, HMD, learning, game technology

1. Introduction

Recently Virtual Reality (VR) has become more widespread and accessible to the common consumer. This study is therefore looking into the idea of using this VR game-technology as a tool for teaching. How to increase the learning outcome of such experiences, especially with all the stimuli a user gets from a Virtual Environment (VE), is the main focus of this research. The authors of this study created a Virtual Reality Environment that transported people back to the time of World War I (WWI) as seen from the Danish fortification, Mosede Fort. This location was chosen because a partnership was already established with the museum as they were looking for new ways of engaging their audience. The focus of the study then was to assess the usefulness of implicit information mediation, where the environment and the characters in the VE were used to convey said information. This study looks into the differences in effectiveness, on retention and learning outcomes, between explicitly and implicitly mediated information. What effect does these methods of communication have on the user's ability to remember facts? The results from the experiment indicated that the implicit procedure was more suited for information retention.

2. Background

Based on results from a previous investigation (Warming et al, 2013), which regarded attention guidance in VR, this study is attempting to observe whether explicitly presented data and use of narrative devices to impart data implicitly, has the same effect on the retention of information that the user experiences. Therefore, a clear definition of the terms implicit and explicit in the context of this study is needed. Bordwell, Thompson and Ashton (1997) describe diegetic and non-diegetic as two different methods of communicating information. Information is diegetic if it exists within the confines of the fictional universe like dialogue between characters and items within the virtual environment. Non-diegetic information describes other artefacts or sounds such as narrators or floating guide arrows originating from outside the virtual environment. Within the context of this study, implicit information mediation is thus considered to be diegetic to its environment. This means that the mediating element is not alien to the environment and is therefore part of the world. Explicit information

mediation, by contrast, is considered to be non-diegetic to its environment. For example the narrator, who is not physically present in the environment but mediates information directly to the user.

2.1 Educational games and learning

Research suggests that it is possible to learn from games when focusing on computer games in an educational context in general. However, Egenfeldt-Nielsen (2006) criticises that many researchers tend to focus on examining if it is possible for games to be effective teaching tools, instead of focusing on investigating whether the results gathered from games differ from other methods of education. The effectiveness and requirements might vary substantially from traditional learning. He further divides educational games into several categories: Edutainment, Commercial educational and Research-based educational games. The current study works with elements from the latter.

These games have a more academic background, with well-founded documentation for learning outcomes, as they have been designed on the basis of edutainment research, and are intended to confront current construction of traditional education. Research-based educational games are developed to integrate educational learning goals by facilitating intrinsic motivation through internal rewards like fun and accomplishment instead of prizes and point scores. Consequently, gameplay should lead to a heightened level of engagement due to its focus on the players learning and playing experience (Schoenau-Fog 2012). Yet, research-based games are often economically limited to low budgets and therefore often also miss the technical quality to compete with the commercial games.

2.2 Engagement

The indication of the previous study was that people who showed interest and were focused, remembered more of the facts imparted to them during the test (Warming et al, 2013),. Engagement theory describes the different reasons for why people ”get into” different media and activities. O’Brien and Toms (2008) created a model for engagement that outlines different aspects of creating an engaging experience, consisting of the broad categories of ”Sensual”, ”Emotional”, and ”Spatiotemporal” engagement. Sensual engagement is what a user hears and sees, and how they interact with the medium. Emotional engagement is the state of the user’s mind as they interact with the medium. Spatiotemporal engagement is the current situation of the user in the real world. Each of these have triggers for engagement and disengagement.

Engagement can come from many places and the current study is focusing on the use of narrative engagement in particular. Schoenau-Fog and Bjørner (2012) describe narrative engagement as instilling curiosity in the user through cues and other narrative devices such as suspense or story-arcs. This encourages the user to experience the story to completion and this may subsequently motivate them further to pay closer attention. Narrative engagement might be used as a way of increasing the amount of information a user retains after the experience as an improved substitute for narrators, facts and figures.

2.2.1 Narrative engagement and learning

Several studies have been conducted concerning the use of narrative as a learning tool; especially in games. Rowe et al (2010) tested the edutainment game “Crystal Island”, a narrative-centered educational software focusing on middle school microbiology. They found that students that were engaged learned more, independently of their prior knowledge of the subject. Rowe et al also mentions off-task behaviour as an indication of disengagement where the user might become bored or distracted. Monitoring off-task behaviour might be a good idea for any test looking into engagement in players. Dede (2009) talks about transfer, the process of taking something learned and applying it, and how it can be measured with sequestered problem-solving or preparations for future learning. While that study focuses on immersion, engagement is still a important part of that and thus narrative plays an important role. Rowe et al and Dede both found that an engaging experience increased learning and transfer.

2.2.2 Suspension of disbelief and the Magic Circle

Adams and Rollings (2006) state that in order to enjoy and follow a narrative the recipient must be in the right state of mind. An important aspect of an engaging narrative is having the user willingly suspend their disbelief and enjoy the story being told. If a user keeps getting distracted by unrealistic or unbefitting circumstances or badly spoken dialogue in the narrative they might experience disengagement. All steps should be taken to make

sure the narrative stays believable and that the voice acting lives up to the same standard. It might be possible to command more suspension of disbelief from the user by maintaining a magic circle. When a reader opens a book or the curtains unfurl at the theatre the audience makes a pact with the artist; that they will believe what they are about to experience long enough for it to affect them emotionally. This is one way to explain the magic circle that has been used since our ancestors sat around a fire, telling stories, 50.000 years ago (Adams and Rollings, 2006). A clearly defined magic circle might help the user to "enter" the virtual world and suspend their disbelief. The user must play along and pretend what they are experiencing is real to a certain degree. This is also an important requirement, when developing virtual environments for VR museum installations.

2.3 A model of engagement

In order to get an overview of the engaging qualities of a game-technology based virtual environment experience, a model (Figure 1) specifically designed for learning and accounting for narrative engagement was developed based on O'Brien and Toms (2008). It is important to keep in mind a variety of parameters when designing a game that has to be both educational and engaging and the model has thus been used as a foundation for the design of the VE. The model defines points that get the player engaged, keep the player engaged and a point that,may disengage the player from the game - it is however possible for the player to become re-engaged after a point of disengagement.

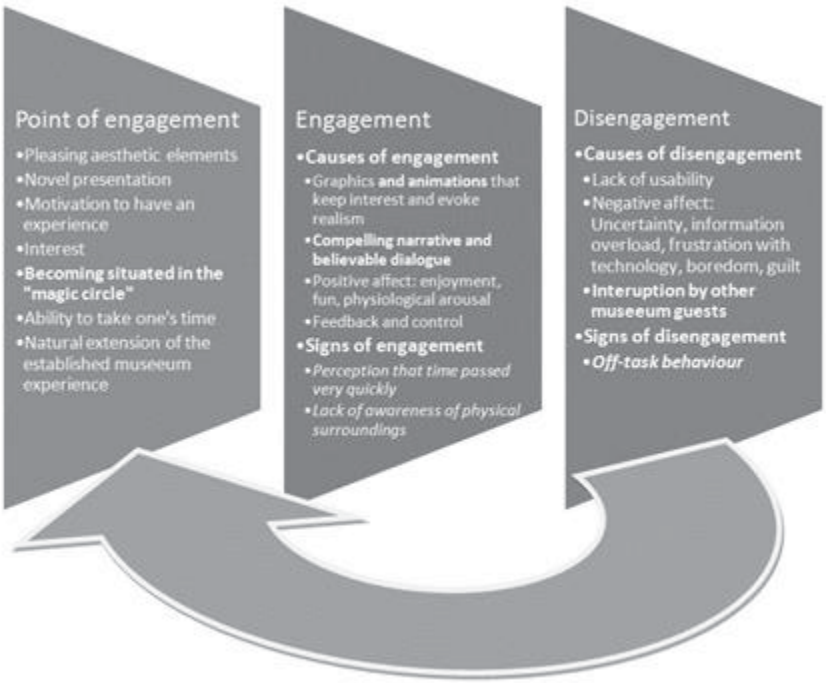


Figure 1: A model for tracking the cycle of engagement and the different aspects which influence it. Based on the model by O'Brien and Toms (2008). The points in bold are specifically added for this study

2.4 Narrative museum experience scale (NMES)

Since this study focuses on interactive narrative content in museum installations, it is valuable to investigate the possibilities for evaluating such experiences. Othman, Petrie and Power (2011) developed a scale to measure visitors' experience in museums called the Museum Experience Scale (MES). This scale helps to get a clearer understanding on how visitors interact with artefacts and exhibits and it gives a valuable empirical evaluation of visitor experiences. Participants were asked to rate statements in four different categories stating their level of agreement on a Likert rating scale from 'strongly disagree' to 'strongly agree'. The four categories are as follows:

- *Engagement*, with exhibitions or exhibits
- *Meaningful Experience*, gained from understanding and information discoveries
- *Knowledge/Learning*, from the interaction with the exhibitions/exhibits or other visitors
- *Emotional Connection*, with the contexts and contents of the exhibits/exhibitions

Since this study also has a focus on narrative engagement, the original MES will be used as a foundation for a new set of questions: the Narrative Museum Experience Scale (NMES). Busselle and Bilandzic (2009) designed a questionnaire for measuring narrative engagement in linear media, such as film or radio dramas; it tests for multiple aspects ranging from empathy to transportation in the sense of having a change of place illusion, and it would be relevant for testing the same aspects for this study. The questionnaire consist of the same Likert Scale design as the MES, where participants rate statements on a 'strongly disagree' to 'strongly agree' Likert scale. Care must be shown when translating the questions to interactive non-linear media due to the fact that information is not provided in a set order. Table 1 contains a list of the questions used for the NMES.

3. Methods

In order to test the difference in retention, based on the implicit and explicit mediation of information an experiment was designed with the following hypotheses:

> *H_0: There is no significant difference between the participants' level of retained information, when presented with information either implicitly/explicitly.*
>
> *H_1: There is a significant difference between the participants' level of retained information, when presented with information either implicitly/explicitly.*

3.1 The experiment

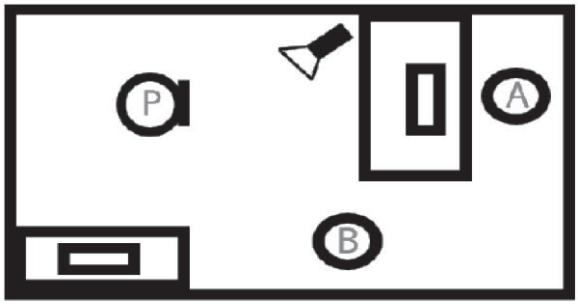
In order to test the difference in retention based on the implicit and explicit mediation of information, an experimental research design was developed. Using the Oculus Rift VR HMD and the game development tool Unity, a virtual environment depicting Mosede Fort in Denmark as it looked during World War I, was created. In this VE there were several objects that the user could look at. This caused the objects to light up and activate a sound sequence that would then mediate a piece of information relating to the object, the fort or Denmark during World War I. Two versions of the VE were created. The first version mediated the information in an implicit way, where information for example was mediated in a conversation between two soldiers. The second version mediated the information explicitly using a narrator and pictures that would appear in the user's field of view. The VE had a total of 8 objects that could meditate information. A screenshot of the VE can be seen in Figure 2. Questionnaires were used to gather information after the experience; one using the NMES to determine engagement levels and one that tested the participants' knowledge about World War I and Mosede Fort.

Figure 2: The virtual environment as seen on a normal screen. Soldiers are looking at the Zeppelin as it approaches the coast

3.2 Experiment design

As the target group includes everyone, who would have an interest in museum exhibitions, participants were chosen using convenience sampling and were all in the age group of 19-31. They were speaking fluently Danish and had not participated in any higher education of history. The participants were randomly divided into two groups; the control group who received the information explicitly and the treatment group who received the information implicitly. Prior to playing the game, participants completed consent forms, which informed them of the possibility of simulation sickness. They were also consenting to being video recorded during the

experience. Participants were also informed that they would have to answer factual questions about what they had learned after the experience.



A:Conductor A, responsible for technical setup
B: Conductor B, responsible for test participant
P: Participant

Figure 3: The setup allows for a test conductor to completely focus on the technical aspects to ensure that everything runs smoothly

Apart from the participants, two test conductors were also present in the room during game play. One was responsible for the technical side of the experiment, while the other was responsible for noting general observations and assisting the participants throughout the experiment. Subsequently, participants completed questionnaires, which was conducted in another room. Both the explicit and implicit participants received the same questionnaire. This helped to2 minimize possible bias due to difference of phrasing. The room setup can be seen in Figure 3.

Table 1: Examples of questions used to gauge participant learning outcomes. (F) indicates a factual question and (U) indicates a question of understanding

A. What year was the Versailles Treaty signed? (F)
B. What did the Versailles Treaty involve? (U)
C. What was the reason World War One started? (U)
D. What year did World War One start? (F)
E. What year did the fighting end? (F)
F. What was the Danish state asked to do, by Germany, in the beginning of World War One and what did this lead to? (U)

3.3 Results

The test was completed by 40 participants, with 20 in each group. The implicit mediation of information testing group had 9 males and 11 females, while the explicit group had 17 males and 3 females. The average age of the participants were 23.7 years in the range 19 – 31 years. As a maximum score, each of the two groups could obtain 520 points combined if each participant got all 26 questions correct.

Table 2: Total points for each group

	Gained points	Percent correct
Explicit group	213	41%
Implicit group	173	33.3%

The 26 questions were divided into two categories that were factual and understanding, depending on their focus. Table 2 and 3 highlights the scores achieved through the two mediated categories.

Table 3: Points as distributed between factual and understanding questions

	Possible points	Gained points	Percent correct
Explicit group			
Factual questions:	320	125	39%
Understanding:	200	88	44%
Implicit group			
Factual questions:	320	93	29%

	Possible points	Gained points	Percent correct
Understanding:	200	70	35%

During the testing a bug in Google Drive's form application caused a loss in data from the explicit test population. Only 10 participants got to answer the Narrative Engagement questions. The following table is still included for comparison, but the narrative engagement part should not be counted as valid. The questions presented were requiring answers in Likert scales ranging from 1 to 10.

Table 4: Combined Likert scale scores of each group on the NMES

	Explicit	Implicit
Engagement:		
''I enjoyed the experience''	7.7	7.7
''I felt I experienced Mosede Fort during WWI''	6.3	6.1
''The experience was interesting''	7.7	8.5
Meaningful Experience:		
''I reflected upon the life at MF in WWI''	5	4.7
''I was satisfied with my experience''	7.3	8
Knowledge/Learning:		
''The information provided was clear and understandable''	8.1	6.8
''I liked the graphics and sound design''	7.1	7.1
''I learnt new things about MF and WWI through my experience''	7.4	6.5
Emotional connection:		
''The experience was a reminder of the history of Denmark''	7.3	7.2
''I felt more present in the experience than in the real world''	6	6.9
''I was overwhelmed by my experience''	6.1	6.6
''I felt connected with the experience''	6.3	6.7
Narrative Engagement:		
''I listened to what was said''	6.1	5.6
''I was surprised that the experience was over so quickly''	5.1	4.9
''At times I forgot I was part of an experiment''	5.3	5.1
''I felt like I was part of the story''	4	4.7
''It was difficult to focus on the experience''	5.2	5
''I could easily follow the events that were occurring during the experience''	7.4	6.8
''At times I found it difficult to follow what was going on''	4.2	4
Averages of the scores of the two groups	6.29	6.26

3.3.1 Observations and comments

Based on the video recordings and observations, the frequency of off-task behaviour was very low and limited to the users testing the HMD and its capabilities. There were no off-task behaviour due to boredom or disengagement in general. Participants were asked what they believed made them remember some information better than other information. Several participants (n=7) noted that they were too enthralled by the environment to notice the information that was presented to them. Another participant wrote: ''Very nicely designed (both image and sound), which had a large influence on my concentration and the value of the experience. The information was combined naturally into the experience, which made it not seem intrusive or artificial - that was very important to my experience.'' - translated from Danish.

3.4 Findings

Wilcoxon rank-sum test of the answers from the questionnaire of historical questions returns a P-value of 35.54% meaning that we can not reject the null-hypothesis of there being no significant difference between the learning outcome of the two versions of the product. No statistical analysis was made on the NMES questionnaire because of loss of data. However, there are indications that the results are similar in the two experiences.

A point worth noting is that the questionnaire testing the participants' knowledge on Mosede Fort and World War I showed that questions about very dynamic events were easier for the implicit group to answer than the

explicit group. The implicit group had the events played out with animations and sound while the explicit group had it explained to them by a narrator. The difference is most marked in a question involving a German Zeppelin flying over the fort and the soldiers responding to that. “What situation at Mosede Fort, could have resulted in Denmark entering the war?” was answered correctly by 12 from the explicit group and 18 from the implicit group. Another question “What type of military equipment was made more reliable and therefore more used during World War One?” was answered correctly by 9 from the explicit group and 15 from the implicit group. This indicates that dynamic events may lead to the participants having a better understanding along with a better recollection of what happened. The level of detail of the answers given by the implicit group, especially for the zeppelin event, was also much higher that the other group.

4. Discussion

The findings indicate that using diegetic events may be useful to help people retain information about events. More detail may be remembered and in general a better understanding of concepts are shown in the answers. Purely factual questions about dates and years were more difficult to retain. This indicates that if it is the facts that are important they could be given directly to the player instead of being hidden in dialogue. In the following, we will summarize and discuss the findings and aspects of the study.

4.1 Using the Oculus Rift in general

While this project builds on studies done with Virtual Reality, this technology is still very new to the majority of people, and it remains to be an unknown territory to the average person (it will become available to the general public within the next year). This means that while this game-based technology can create interest in the user, it might also be the source of unintentional distraction. On several occasions, test subjects commented that there were several moments where they did not pay full attention, because they were deeply engaged in admiring the Oculus Rift VR technology. In the coming years more and more people will get the opportunity to try a VR experience, and they will most likely be more used to the technology and pay more attention to the content of the experience.

4.2 Considerations concerning the information mediation

The purpose of this study concerns mediation of information inside a virtual reality in regards to supporting retention. The mediation of information was divided into two types. One type was explicit and non-diegetic, while the other was implicit and diegetic. The final experiment of this study did not find differences between the two setups that were significant enough on a large scale. However, answers to the individual questions asked in the questionnaire, reveals that larger differences are evident. When studying some of the answers given in the test, several of the factual questions were answered more precisely by participants using the explicit setup. Furthermore, one certain episode, such as the Zeppelin event, gathered better results in the implicit setup than in the explicit. A reason for factual data seeming to work better in the explicit setup could be, that people are trained to listen to a narrator, as opposed to a conversation. Another reason could be, that participants were simply distracted by the voice-acting in the implicit setup. The 2D images, used by the explicit version of the game, could be a good way to inform the participant that they are learning, and that they should be relating this experience to actual historic events. This could have been a factor during the experiment. It should also be noted that the explicit group and a larger group of males than the implicit group, while this may not have an effect it should be noted.

4.3 Users’ comments on what helped them remember

During the questionnaire part of the experiment sessions, the participants were asked, what helped them to remember the information during the session. For the Implicit version there is a pattern, which indicates that participants had a hard time remembering the factorial information (such as dates, names ect.) but that they remembered events and conversations better. In the Explicit version, participants commented that information with closely related objects, like the calendar and the map of the fort, helped them remember the information. Some comments that were repeated in both versions were that participants had a hard time paying attention and when the participants could relate to the information they could remember it better – the price of the soldiers’ cigarettes were a popular example. This should also be seen in relation to information which participants could link to their own life and experiences.

4.4 The users' experience and learning outcomes after using the installation

One of the main issues when testing was that the experience of trying out the novel VR game technology seemed to outweigh participants' focus on the educational purpose of the experiment. In other words, the mediation of information was affected significantly by the overall experience. This relates closely to the idea stated by Egenfeldt-Nielsen (2006), that a research-based educational game designed, based on a cognitivist theory which work to facilitate intrinsic motivation, will lead to a strong sense of player experience, where the player will focus more on the game play than the educational content gained from the game. This indicates, that when working with VR, one must be aware of the risk that the educational outcome can be drowned out by player experience and a possible high level of engagement. Therefore, the combination of fun and learning must be carefully considered, in order to not exclude one for the other.

5. Conclusion

An important challenge while testing for differences within virtual reality, especially with an installation supposed to be entertaining, is the novelty effect and the people who respond to this by being unable to concentrate on the content. We hope that VR technology will keep increasing in popularity and some day people will be as acclimatized to it as they are to TV. Even though this study has shown indications that there are strengths in both implicit and explicit mediation of information, with a small advantage to implicit, we conclude that it will be difficult to get real data on the effectiveness of learning through VR, as long a the novelty of VR is as distracting as it currently is. However, the novelty factor might play in favor for a real installation at the Mosede Fort exhibition as it might just draw in people with its novelty factor and only later begin to impart knowledge like it was designed to do. In terms of which mediation method is best for teaching history when working with game-based technology, it is important to remember that these are tools to be used in combination and that one is not necessarily more effective than the other. If it is an understanding of a specific situation that you want to convey, then it seems like doing it with dynamic and diegetic events is a good strategy.

References

Adams, E. (2014). *Fundamentals of game design.* Pearson Education.

Bordwell, D., Thompson, K. and Ashton, J. (1997). *Film art: an introduction.* (Vol. 7). New York: McGraw-Hill.

Busselle, R. and Bilandzic, H. (2009). "Measuring narrative engagement". *Media Psychology*, Vol 12, no 4, pp 321-347.

Dede, C. (2009). "Immersive interfaces for engagement and learning". *Science*.Vol. 323, no. 5910, pp 66-69.

Egenfeldt-Nielsen, S. (2006). Overview of research on the educational use of video games. *Digital kompetanse*, Vol. 1, no 3, pp 184-213.

O'Brien, H. L. and Toms, E. G. (2008). "What is user engagement? A conceptual framework for defining user engagement with technology". *Journal of the American Society for Information Science and Technology*, Vol. 59, no 6, pp 938-955.

Okan, Z. (2003). "Edutainment: is learning at risk?".*British Journal of Educational Technology*, Vol. 34, no 3, pp 255-264.

Othman, M. K., Petrie, H. and Power, C. (2011). "Engaging visitors in museums with technology: scales for the measurement of visitor and multimedia guide experience". *Human-Computer Interaction–INTERACT 2011*, pp. 92-99. Springer Berlin Heidelberg.

Rowe, J. P., Shores, L. R., Mott, B. W. and Lester, J. C. (2010, January). "Integrating learning and engagement in narrative-centered learning environments", *Intelligent Tutoring Systems*, pp. 166-177. Springer Berlin Heidelberg.

Schoenau-Fog, H. (2012). "Teaching Serious Issues through Player Engagement in an Interactive Experiential Learning Scenario". In *Eludamos. Journal for Computer Game Culture*. Vol. 6, no 1, pp 53-70.

Schoenau-Fog, H. and Bjørner, T. (2012). "Sure, I Would Like to Continue" A Method for Mapping the Experience of Engagement in Video Games. *Bulletin of Science, Technology & Society*, *32*(5), 405-412.

Warming, C., Witt, M., Klubien, J., Moesgaard, T. M. and Fiss. J. (2013) "Guiding Attention in a Virtual Reality: An Investigation into Implicit and Explicit Attention Guiding in a Virtual Reality Environment and its Effects on Information Retention". Project report (P5), Aalborg University, Denmark.